

IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases

IEEE Power and Energy Society

Sponsored by the
Power System Relaying Committee



IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std C57.13.3™-2014
(Revision of
IEEE Std C57.13.3-2005)

This is a Redline Document produced by Techstreet, a business of Thomson Reuters.

This document is intended to provide users with an indication of changes from one edition to the next. It includes a full-text version of the new document, plus an indication of changes from the previous version.

Redlines are designed to save time and improve efficiencies by using the latest software technology to find and highlight document changes. More professionals are using valuable new technologies like redlines, to help improve outcomes in a fastpaced global business world.

Because it may not be technically possible to capture all changes accurately, it is recommended that users consult previous editions as appropriate. In all cases, only the current base version of this publication is to be considered the official document.

Redline Processing Notes:

1. ~~Red Text~~ - Red strikethrough text denotes deletions.
2. Blue Text - Blue underlined text denotes modifications and additions.

IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases

Sponsor

Power System Relaying Committee
of the
IEEE Power and Energy Society

Approved 10 December 2014

IEEE-SA Standards Board

Abstract: General and specific recommendations for grounding current and voltage transformer secondary circuits and cases of connected equipment are covered in this guide. Although most diagrams included in this guide show relaying applications, the recommended practices apply equally to metering and other areas where instrument transformers are used. Grounding practices presently used, and practices that were not previously reported, are included in this guide. Specifically, a review of other than North American grounding practices is included.

Keywords: Capacitive voltage transformer, combined metering unit, current transformer, grounding of cases of instrument transformers, grounding secondary circuits of instrument transformers, IEEE C57.13.3™, instrument transformer, linear coupler, low energy transducer, resistive voltage transformer, voltage transformer.

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2015 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 23 January 2015. Printed in the United States of America.

IEEE and NESC are registered trademarks in the U.S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated.

National Electrical Code, NEC, and NFPA 70 are registered trademarks of the National Fire Protection Association, Inc.

PDF: ISBN 978-0-7381-9423-3 STD20038
Print: ISBN 978-0-7381-9424-0 STDPD20038

IEEE prohibits discrimination, harassment, and bullying.

For more information, visit <http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html>.

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page, appear in all standards and may be found under the heading “Important Notice” or “Important Notices and Disclaimers Concerning IEEE Standards Documents.”

Notice and Disclaimer of Liability Concerning the Use of IEEE Standards Documents

IEEE Standards documents (standards, recommended practices, and guides), both full-use and trial-use, are developed within IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (“IEEE-SA”) Standards Board. IEEE (“the Institute”) develops its standards through a consensus development process, approved by the American National Standards Institute (“ANSI”), which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and participate without compensation from IEEE. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims all warranties (express, implied and statutory) not included in this or any other document relating to the standard, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; and quality, accuracy, effectiveness, currency, or completeness of material. In addition, IEEE disclaims any and all conditions relating to: results; and workmanlike effort. IEEE standards documents are supplied “AS IS” and “WITH ALL FAULTS.”

Use of an IEEE standard is wholly voluntary. The existence of an IEEE standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

IN NO EVENT SHALL IEEE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Translations

The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE should be considered the approved IEEE standard.

Official statements

A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered or inferred to be the official position of IEEE or any of its committees and shall not be considered to be, or be relied upon as, a formal position of IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position of IEEE.

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide consulting information or advice pertaining to IEEE Standards documents. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to comments or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in revisions to an IEEE standard is welcome to join the relevant IEEE working group.

Comments on standards should be submitted to the following address:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854 USA

Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

IEEE draft and approved standards are copyrighted by IEEE under U.S. and international copyright laws. They are made available by IEEE and are adopted for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making these documents available for use and adoption by public authorities and private users, IEEE does not waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate fee, IEEE will grant users a limited, non-exclusive license to photocopy portions of any individual standard for company or organizational internal use or individual, non-commercial use only. To arrange for payment of licensing fees, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Updating of IEEE Standards documents

Users of IEEE Standards documents should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect.

Every IEEE standard is subjected to review at least every ten years. When a document is more than ten years old and has not undergone a revision process, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE standard.

In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE-SA Website at <http://ieeexplore.ieee.org/xpl/standards.jsp> or contact IEEE at the address listed previously. For more information about the IEEE-SA or IEEE's standards development process, visit the IEEE-SA Website at <http://standards.ieee.org>.

Errata

Errata, if any, for all IEEE standards can be accessed on the IEEE-SA Website at the following URL: <http://standards.ieee.org/findstds/errata/index.html>. Users are encouraged to check this URL for errata periodically.

Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE-SA Website at <http://standards.ieee.org/about/sasb/patcom/patents.html>. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims, or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

Participants

At the time this IEEE guide was completed, the PC57.13.3 Working Group for Grounding of Instrument Transformer Secondary Circuits and Cases had the following membership:

Brian P. Mugalian, *Chair*
Bruce A. Magruder, *Vice Chair*

George Bartok
Dean Bender
Robert Beresh
Lee Bigham
Zeeky Bukhala
Stephen Conrad
Dominick Fontana

Gerald Johnson
Gary Kobet
Jeff Long
Dhirenkumar Patel
Bruce Pickett
Jeff Pond
Mohindar Sachdev

Donald Sevcik
Mike Stojak
Joe Uchiyama
Johan Vandenberg
Delbert D. Weers
Ray Young
Richard Young

The following members of the individual balloting committee voted on this guide. Balloters may have voted for approval, disapproval, or abstention.

William Ackerman
Ali Al Awazi
Mihaela Albu
Steven Alexanderson
Jay Anderson
Jeffrey Barsch
George Bartok
Michael Basler
Philip Beaumont
Kenneth Behrendt
Robert Beresh
Martin Best
Steven Bezner
Wallace Binder
Gustavo Brunello
Zeeky Bukhala
Paul Cardinal
Stephen Conrad
Randall Crellin
Ratan Das
Gary Donner
Randall Dotson
Sourav Dutta
Doaa Galal
Frank Gerleve
Jeffrey Gilbert
Jalal Gohari
Stephen Grier
Randall Groves
Ajit Gwal
Scott Hietpas

Jerry Hohn
David Horvath
Gerald Johnson
Laszlo Kadar
John Kay
Gael Kennedy
Yuri Khersonsky
James Kinney
Gary Kobet
Joseph L. Koepfinger
Boris Kogan
Jim Kulchisky
Saumen Kundu
Chung-Yiu Lam
Michael Lauxman
Greg Luri
Bruce Mackie
Bruce A. Magruder
John Miller
Venkatesh Minisandram
Brian P. Mugalian
Randolph Mullikin
Jerry Murphy
Arthur Neubauer
Michael Newman
Joe Nims
Gary Nissen
James O'Brien
Gearold O. H. Eidhin
Ted Olsen
Lorraine Padden
Mirko Palazzo

Dhirenkumar Patel
Bruce Pickett
Samala Santosh Reddy
Michael Roberts
Charles Rogers
Zoltan Roman
Jesse Rorabaugh
Mohindar Sachdev
Steven Sano
Bartien Sayogo
Robert Seitz
Donald Sevcik
Veselin Skendzic
James Smith
Jeremy Smith
Jerry Smith
Gary Smullin
Gary Stodter
Michael Thompson
Robert Thornton-Jones
Demetrios Tziouvaras
Joe Uchiyama
John Vergis
Ilia Voloh
John Wang
Delbert D. Weers
Kenneth White
Philip Winston
Ray Young
Richard Young
Jian Yu

When the IEEE-SA Standards Board approved this guide on 10 December 2014, it had the following membership:

John Kulick, *Chair*
Jon Walter Rosdahl, *Vice Chair*
Richard H. Hulett, *Past Chair*
Konstantinos Karachalios, *Secretary*

Peter Balma
Farooq Bari
Ted Burse
Clint Chaplin
Stephen Dukes
Jean-Philippe Faure
Gary Hoffman

Michael Janezic
Jeffrey Katz
Joseph L. Koepfinger*
David J. Law
Hung Ling
Oleg Logvinov
T. W. Olsen
Glenn Parsons

Ron Petersen
Adrian Stephens
Peter Sutherland
Yatin Trivedi
Phil Winston
Don Wright
Yu Yuan

*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Richard DeBlasio, *DOE Representative*
Michael Janezic, *NIST Representative*

Patrick Gibbons
IEEE-SA Content Production and Management

Erin Spiewak
IEEE-SA Technical Program Operations

Introduction

This introduction is not part of IEEE Std C57.13.3-2014, IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.

The primary emphases of this guide are personnel safety and proper performance of relays at the electric power system frequencies. The grounding and shielding of cables and other grounding considerations are not addressed. However, references dealing with these and related subjects are included in the bibliography (see Annex D).

Historically, it has been a common practice in the U.S. to connect the secondary circuits of current transformers (CTs) and voltage transformers (VTs) to the station ground. The present preferred practice is to locate a ground on the instrument transformer secondary circuit, along with suitable ground isolation test facilities, at the first point of application (switchboard or relay panel). The circuit ground isolation facilities make it convenient to test the integrity of the insulation from ground.

Previous publications have made significant contributions toward making the grounding practices more consistent in some areas. This guide includes the contributions that are generally practiced today, makes revisions where present experience and practice show them to be desirable, and suggests grounding techniques in new areas of interest. Diagrams are included to illustrate the grounding techniques.

This guide contains general and specific recommendations for grounding CT and VT secondary circuits and cases of connected equipment. The recommended practices apply to all transformers of this type, including capacitive VTs and linear couplers, irrespective of the voltage of the primary circuit or whether the primary windings are connected to the power circuits or are connected to the secondary circuits of other transformers, such as auxiliary CTs or VTs. Most diagrams included in this guide show relaying applications, but the practices are equally relevant to metering and other areas where instrument transformers are used.

Exceptions to grounding are permissible or are sometimes required when advantages obtained by not grounding, in certain instances or in certain types of installations, are considered to outweigh the safety or other advantages obtained by grounding. Such exceptions should comply with the recommendations of the National Electrical Safety Code[®] (NESC[®]) (Accredited Standards Committee C-2).^{a, b}

^a The NEC is published by the National Fire Protection Association (<http://www.nfpa.org/>). It is also available from the IEEE at <http://www.techstreet.com/ieeegate.html>.

^b The NESC is available from The Institute of Electrical and Electronics Engineers (<http://standards.ieee.org/>).

Contents

1. Overview	1
1.1 Introduction	1
1.2 Scope	2
1.3 Purpose	2
2. Normative references.....	2
3. Definitions	3
4. Need for grounding secondary circuits of instrument transformers and cases	3
5. Grounding of instrument transformer secondary circuits	4
5.1 General	4
5.2 Background.....	4
5.3 Ground connection to only one point in the secondary circuit	4
5.4 Recommended point of grounding	5
5.5 Location of connection to ground.....	6
5.6 Minimum size of conductor for ground connection.....	8
5.7 Ground connection isolation test facilities.....	8
6. Grounding of instrument transformer cases and cases of connected equipment	21
6.1 Metallic or conductive case grounding.....	21
6.2 Internal conductive parts—insulated cases.....	21
6.3 Ungrounded metallic or conductive case.....	21
7. Exceptions to grounding.....	22
8. Grounding of low-energy transducers	22
8.1 General	22
8.2 Interconnection wiring practices.....	23
Annex A (informative) Issues to consider for shielded cable applications for instrument transformers	25
A.1 General.....	25
A.2 CTs installed over shielded cables, metal bushing collars, or conduits	25
Annex B (informative) IEEE, IEC, and other standards reviewed by the I-8—Revision of C57.13.3 Working Group.....	28
Annex C (informative) Examples of problems introduced by simultaneous yard/house grounding in CT/VT circuits	30
C.1 Introduction.....	30
C.2 Example 1: Multiple grounds in CT secondary circuits introduced by isolation/test facilities	30
C.3 Example 2 - Multiple grounds in VT secondary circuits introduced microprocessor relay surge suppression	34
Annex D (informative) Bibliography	41

IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases

IMPORTANT NOTICE: IEEE Standards documents are not intended to ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. Implementers of IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.

This IEEE document is made available for use subject to important notices and legal disclaimers. These notices and disclaimers appear in all publications containing this document and may be found under the heading "Important Notice" or "Important Notices and Disclaimers Concerning IEEE Documents." They can also be obtained on request from IEEE or viewed at <http://standards.ieee.org/IPR/disclaimers.html>.

1. Overview

1.1 Background

The practices described in this guide apply to all instrument transformers (ITs), including voltage transformers (VTs), capacitive voltage transformers (~~VTs~~CVTs) ~~and~~, resistive voltage transformers (RVTs), current transformers (CTs), linear couplers (LCs), and combined metering units (MUs), irrespective of primary voltage or whether the primary windings are connected to, or are in, power circuits or are connected in the secondary circuits of other transformers as auxiliary CTs or VTs. For the purpose of this document, CVTs, RVTs, and VTs will be referred to as VTs.

This guide does not discuss the grounding of some applications. For example, grounding of gas insulated substations and metal clad switchgear is not discussed in this guide; the reader will find these topics addressed in IEEE Std 242™.¹ The grounding of circuits of core-balance CTs is also not discussed in this guide. The reader can also find this information in IEEE Std 242. Another issue that is not discussed in this guide is the practice of using separate safety and control grounds. For discussion on this topic, the reader is directed to IEEE Std 665™.

1.2 Scope

This guide contains general and specific recommendations for grounding current and voltage transformer secondary circuits and cases of connected equipment. The practices recommended apply to all transformers of this type, including capacitive voltage transformers and linear couplers, irrespective of primary voltage or whether the primary windings are connected to, or are in, power circuits or are connected in the secondary circuits of other transformers as auxiliary current transformers or voltage transformers. Although most diagrams included in this guide show relaying applications, the recommended practices apply equally to metering and other areas where instrument transformers are used.

Exceptions to grounding are permissible or sometimes required where advantages obtained by not grounding, in certain instances or in certain types of installations, are considered to outweigh the advantages obtained by grounding.

The scope of the guide includes ~~the~~ grounding practices presently used and ~~the~~ practices that were not previously reported. Specifically, ~~the issue~~ a review of ~~the other than North American~~ grounding ~~of cases of electronic transducers~~ practices is ~~addressed~~ included.

¹ ~~For~~ Information on normative references, ~~see~~ can be found in Clause 2.

1.3 Purpose

This guide provides information on the grounding of the following:

- Secondary circuits of electromagnetic CT and VT circuits
- Cases of relays, CTs, and VTs
- Secondary circuits of optoelectronic CTs and VTs

The primary emphases of this guide are personnel safety and proper performance of relays at electric power frequencies.

2. Normative references

The following referenced documents are indispensable for the application of this document ([i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained](#)). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

Accredited Standards Committee C2, National Electrical Safety Code® (NESC®).²

² The NESC is available from the Institute of Electrical and Electronics Engineers, ~~445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA~~ (<http://standards.ieee.org/>).

IEEE Std 242™, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.^{3, 4}

IEEE Std 525™, IEEE Guide for the Design and Installation of Cable Systems in Substations.

IEEE Std 665™, IEEE Guide for Generating Station Grounding.

IEEE Std C62.92™, IEEE Guide for the Application of Neutral Grounding in Electrical Utility Systems.

NFPA 70: National Electrical Code® (NEC®).⁵

3. Definitions

For the purposes of this document, the following terms and definitions ~~of terms used in this guide, see apply. The IEEE Standards C37.100™-1992 [B8]⁵ and The Authoritative Dictionary of IEEE Standards Terms [B2]~~ Online should be consulted for terms not defined in this clause.⁶

³ IEEE publications are available from the Institute of Electrical and Electronics Engineers, ~~445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA~~ (<http://standards.ieee.org/>).

⁴ The IEEE standards or products referred to in this clause are trademarks of the Institute of Electrical and Electronics Engineers, Inc.

⁵ The NEC is published by the National Fire Protection Association, ~~Batterymarch Park, Quincy, MA 02269, USA~~ (<http://www.nfpa.org/>). ~~Copies are It is~~ also available from the ~~Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA~~ (<http://standards.ieee.org/>) ~~IEEE at~~ <http://www.techstreet.com/ieeegate.html>.

⁶ IEEE Standards Dictionary Online subscription is available at:
http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html.

resistive potential device (RPD): See: resistive voltage transformer.

resistive voltage transformer (RVT): A device having a constant-current output producing an output voltage which is directly proportional to the voltage applied to the line terminal using a resistor in the stack to couple to the high voltage primary connection, which is connected to an internal step down transformer.

synchroscope: An instrument for indicating whether two periodic quantities are synchronous. It usually embodies a continuously rotatable element, the position of which at any time is a measure of the instantaneous phase difference between the quantities. While its speed of rotation indicates the frequency difference between the quantities, its direction of rotation indicates which of the quantities is of higher frequency.

4. Need for grounding secondary circuits of instrument transformers and cases

It is necessary to ground secondary circuits of instrument transformers for protecting the protection, monitoring, and control equipment that are connected to them and for the safety of personnel who might come into contact with them. The primary circuits of instrument transformers are at high voltages; in many cases, they are in the range of hundreds of kilovolts. There is a (stray) capacitance between the high-voltage circuit and the secondary circuit of the instrument transformer. If a secondary circuit is not grounded, there will be a capacitance between the secondary circuit and the ground. The capacitances between the high-voltage circuit and the secondary circuit of the instrument transformer, and the capacitance between the secondary circuit and ground, are now connected in series and act like a voltage divider. A charge could accumulate on the secondary winding of the instrument transformer. Depending on the relative values of the two capacitances, the electrostatic potential of the secondary circuit with respect to ground could be substantial. This potential rise of the secondary circuit could damage the equipment connected to it; one of the failure modes could be insulation failure in the protection and control devices. The high electrostatic potential of the secondary circuit of the instrument transformer would be a hazard for personnel who might come into contact with the circuit. Because of these reasons, grounding has received attention in many standards, recommended practices, and guides. While these standards provide sufficient guidance, the reader is advised to make certain that the grounding regulations provided in the National Electrical Code® (NEC®) (NFPA 70) and the National Electrical Safety Code® (NESC®) (Accredited Standards Committee C-2) are always adhered to. (Article 90.2 (A) of the NEC lists the installations that are covered by the Code, and Article 90.2 (B) lists the installations that are not covered by the Code. ~~For immediate reference, Article 90.2 of the NEC is reproduced in Annex C.~~) If the secondary circuit of an instrument transformer is grounded, the capacitance between the secondary circuit and ground is short-circuited and electrostatic potential does not build up on the secondary circuit.

Similarly, there is a (stray) capacitance between the primary circuit and the case of a device used in the power system environment. If the case is not grounded, there is a (stray) capacitance between the case and the ground. These two capacitances form a series circuit that acts as a voltage divider. In this case also, the electrostatic potential of the case could be substantial. This would be a hazard for personnel who might come in contact with the case. The grounding of the case short-circuits the capacitance between the case and the ground and keeps the case at ground potential—eliminating the hazard. As stated in the previous paragraph, the reader must adhere to the requirements of the NEC and the NESC.

WARNING

Grounding of secondary circuits is an issue of safety of personnel and equipment connected to the secondary circuits. The reader is urged to consider it seriously and follow the stipulations of relevant standards and always adhere to the stipulations of the NEC and the NESC. Article 90.2 (A) of the NEC lists the installations that are covered by the Code, and Article 90.2 (B) lists the installations that are not covered by the Code. ~~For immediate reference of the readers, Article 90.2 of the NEC is reproduced in Annex C.~~

5. Grounding of instrument transformer secondary circuits

5.1 General

The issue of grounding instrument transformers requires insight into the operation of power systems during normal working conditions and during faults between one or more phases to ground. In these cases, parts of the fault currents flow in the ground path and raise the voltage of the grounding grids in generating stations and substations. When this happens, different locations in the generating stations and substations are at different potentials. These differences are taken into consideration when choosing the manner in which the secondary circuits of the CTs and VTs are connected. This clause examines the relevant issues on the grounding needs and practices.

Specific issues addressed in this clause include grounding at a single location on a secondary circuit, location of the ground, marking of ground connections, and the minimum size of conductor used for grounding the secondary circuits.

5.2 Background

Each secondary circuit of CTs and VTs is usually a completely self-contained metallic circuit. The circuit is insulated from ground, except at one point in the circuit where it is solidly grounded through a conductor of adequate size. (See 5.6 for conductor size and [5 see Clause 7](#) for permissible exceptions.)

For the purposes of this guide, an instrument transformer (CT or VT) secondary circuit consists of a set of three-phase secondary windings of the instrument transformers and all the coils, contacts, and other components connected to those windings by insulated metallic wires. In single-phase applications, the instrument transformer secondary circuit consists of the secondary winding of the instrument transformer and all the coils, contacts, and other components connected to that winding by insulated metallic wires.

5.3 Ground connection to only one point in the secondary circuit

The instrument transformer secondary circuit, irrespective of the number of instrument transformer secondary windings connected to or in that circuit, is usually connected to the station ground at only one point. Usually, the common return circuit for two or more transformers is made into a common neutral. This neutral is then connected to the station grounding grid at only one point, so that the station grounding grid does not become part of the instrument transformer secondary circuit.

The reasons for making the ground connection only at a single point in each circuit are as follows:

- a) Different locations on the station grounding grid are at different potentials when fault currents flow through the grounding grid. If the secondary circuits are grounded at more than one location, the potential differences between the grounding locations during faults can result in current flows through the relays and meters connected to the circuit. These additional currents could cause the relays to perform incorrectly and could result in providing incorrect measurements by meters. If the neutral conductor of the secondary circuit is connected to ground at multiple locations, large amounts of current could flow in the neutral conductor that could overheat this conductor and damage it.
- b) Sometimes it is desirable to test the integrity of the insulation of the secondary circuit to check for the existence of accidental grounds on the circuit. Grounding the secondary circuit at one location and making a provision for isolating the circuit from the ground comes in handy when the test is to be conducted.

For convenience, some users connect individual neutrals or wye points of two or more sets of instrument transformers to form a neutral bus, which is then connected from one point to the station grounding grid. Connecting the neutrals or wye points of two or more sets of instrument transformers would cause difficulty when insulation tests between the circuits connected to a set of instrument transformers and ground are to be conducted. Removing the ground connection for conducting the test on the circuits connected to one set of instrument transformers would isolate the secondary circuits of all the instrument transformers from ground while they could be in operation. The arrangements for grounding secondary circuits connected to CTs and VTs, which facilitate the testing of those circuits, are described in 5.7.

5.4 Recommended point of grounding

The instrument transformer secondary circuits are generally grounded at one point. The circuits shall preferably be connected to ground at the first point of application of the circuit (switchboard or relay panel). This practice provides maximum protection for personnel and connected equipment at the switchboard, which is the location where overvoltages are likely to be experienced.

It may be necessary to ground the instrument transformer secondary circuit at another location if the arrangement of the secondary windings or devices connected to the circuit makes this necessary for obtaining correct equipment performance or for other justifiable reasons.

If the advantages of the desired performance are considered to outweigh the advantages of grounding of the secondary windings directly, the secondary windings are grounded through the coils of relays, instruments, meters, and other elements, such as auxiliary transformers, which form part of the secondary circuit.

Some specific examples of this practice follow:

- a) One end of the instrument transformer secondary winding in a circuit supplied by a single transformer is connected to a single ground.
- b) The common point of connection of the secondary windings of all instrument transformers in a circuit supplied by two or more transformers is connected to a single ground. This applies to situations where two or more instrument transformers, or sets of instrument transformer secondary windings, are used in any combination that has a common secondary return circuit, including the following:
 - 1) Parallel or cross-connected secondary windings.
 - 2) Three single-phase transformers wye-connected to form a three-phase connection.
 - 3) Two series, open-wye, or open-delta connected instrument transformer secondaries.
- c) The secondary circuit of three or more CTs or VTs connected in delta, or in some other manner, so that no common point of connection is available for all of the secondary circuits. A point that is common to most of the secondary circuits is connected to ground.

- d) When the secondary windings of two or more sets of CTs are interconnected but they cannot have a common neutral connection, then the secondary neutral connection for the greatest number of the CTs is connected to ground. A specific case occurs where some of the interconnected CTs have delta-connected secondary windings for supplying differential protective relays.

5.5 Location of connection to ground

5.5.1 General

The following two practices are used for grounding instrument transformer secondary circuits:

- a) The circuit is connected to ground where the instrument transformers are located.
- b) The circuit is connected to ground where relays and other devices connected to the circuit are located.

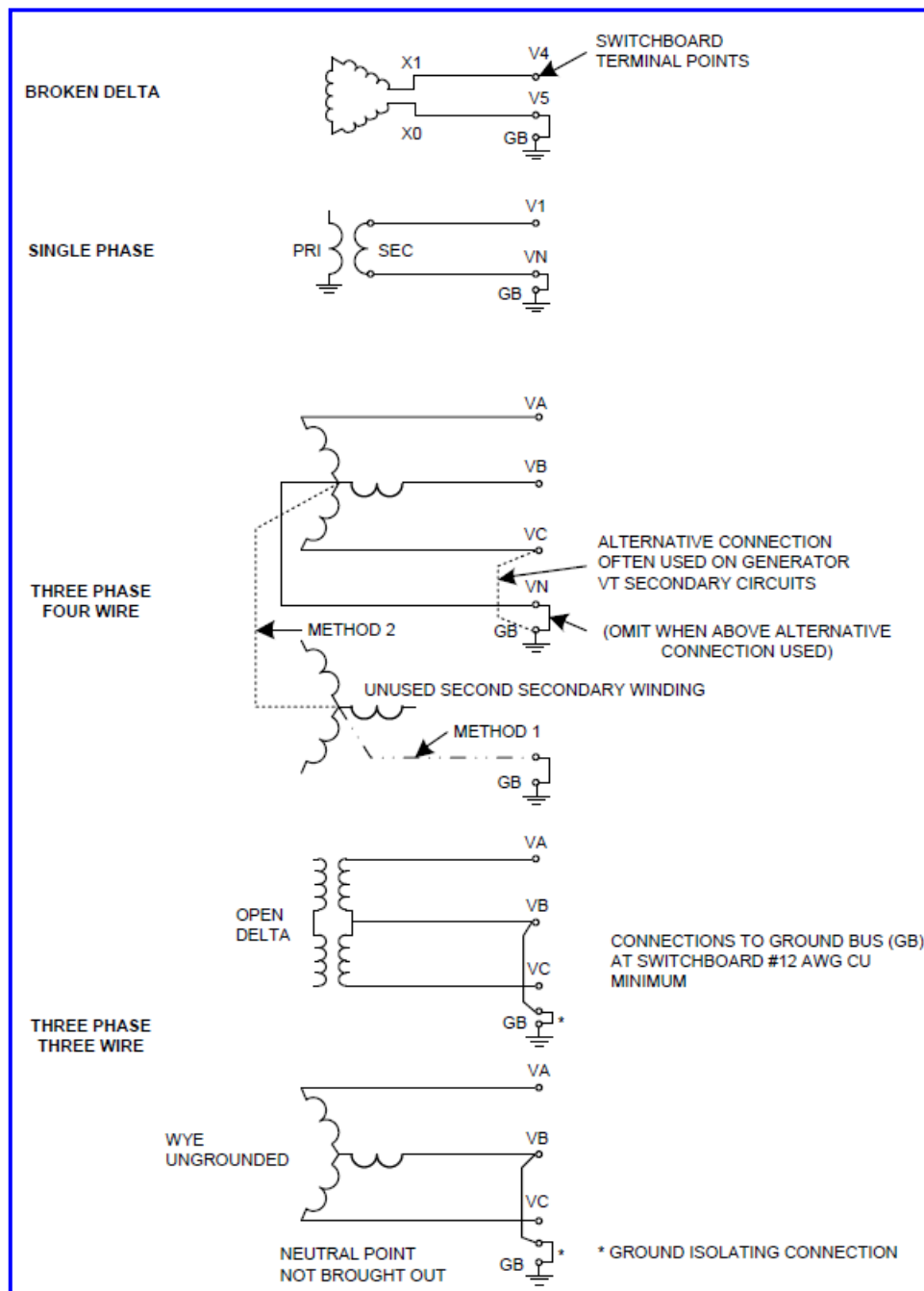
Connecting the instrument transformer secondary circuit to ground at or near the instrument transformer location limits the voltage stresses on the secondary windings of the instrument transformers. The secondary burden devices are mostly located at the switchboard that could be several hundred meters from where the instrument transformers are located. These devices would be subjected to significant overvoltages during power system short circuits to ground.

Because test and operating personnel are more likely to be working at the switchboard, rather than at the instrument transformer location, grounding the instrument transformer secondary circuits at the first switchboard entry, as is shown in Figure 1 for grounding secondary circuits of VTs, is more desirable. This option provides better protection for personnel and equipment connected to the secondary circuit. Additionally, locating the ground at the first point of application makes it more convenient to conduct insulation tests as already stated in item b) of 5.3.

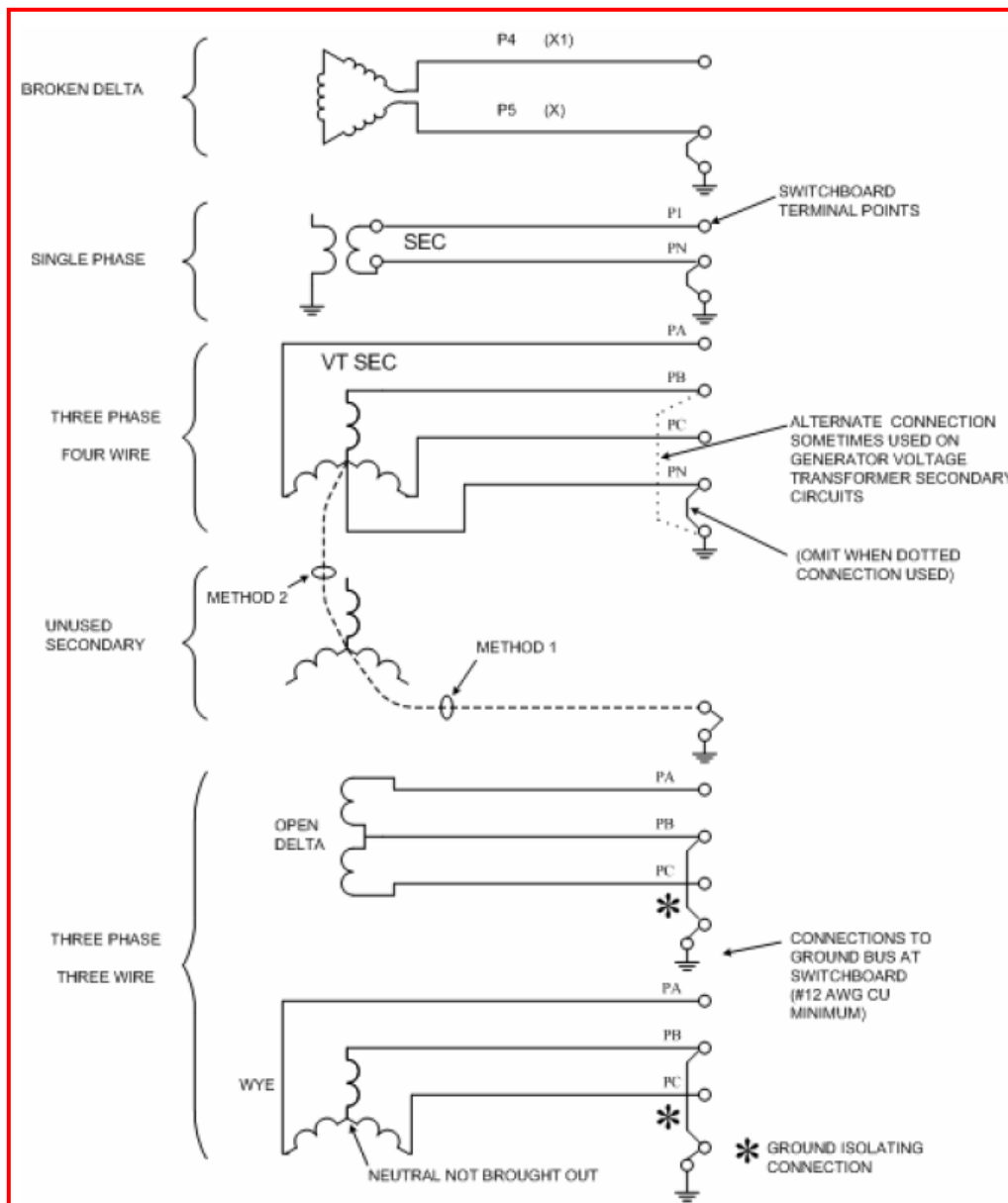
A disadvantage of grounding the secondary circuit at the location of the instrument transformer is that the secondary circuit could be grounded at the switchboard as well—not realizing that the circuit has already been grounded at the location of the instrument transformer.

5.5.2 Unused secondary windings of instrument transformers

In many situations, some of the secondary windings of instrument transformers are not used and no circuit is connected to the windings. In such cases, the secondary winding of the instrument transformer is connected to ground where the instrument transformer is located. If a circuit is connected to the instrument transformer secondary and is taken to a switchboard but is not connected to any measurement or protection device, the circuit is grounded at the first point of entry to the switchboard (see Method 1 in Figure 1).



(New)

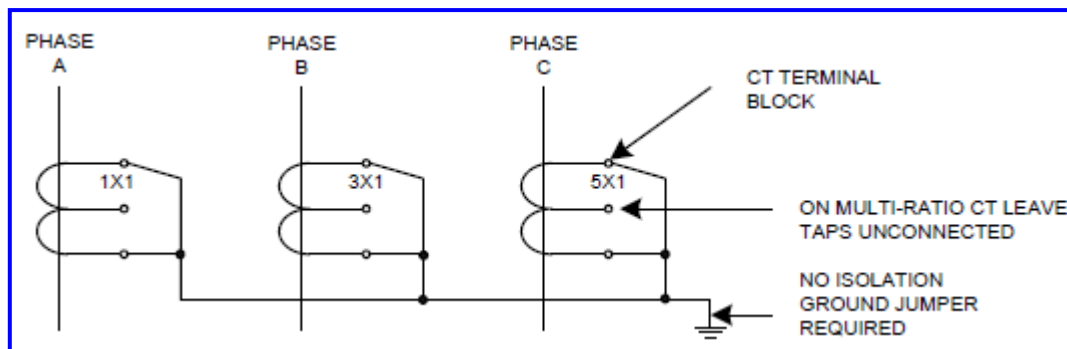


(Deleted)

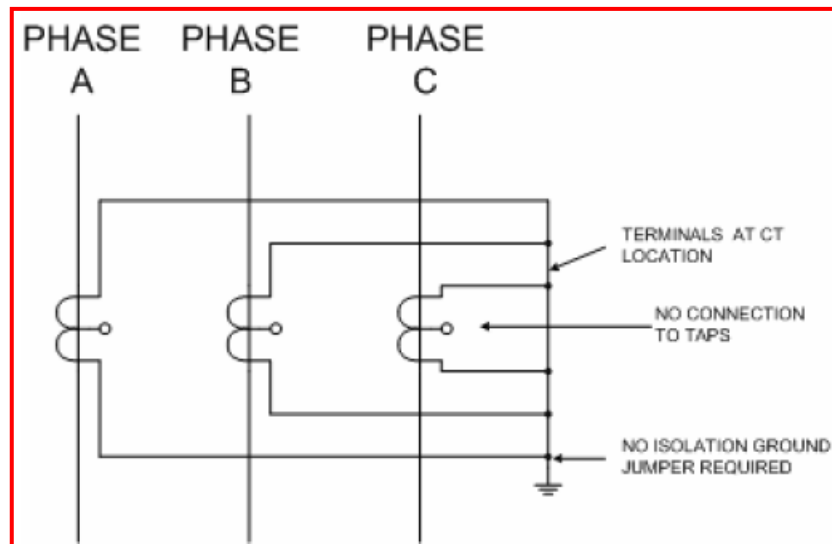
Figure 1—Methods of grounding VT secondary circuits

However, grounding the unused winding at the switchboard creates a much greater probability that noise will be coupled from the unused winding to the used winding during ground faults on the system. If noise coupling is a problem, connection of the unused winding to the used winding neutral at the transformer location becomes necessary (see Method 2 in Figure 1).

When it is necessary or desirable to ground the secondary winding of an instrument transformer where it is located, such as for an unused winding, the connection from the instrument transformer secondary circuit is connected to the grounding grid directly, as is shown in Figure 2.



(New)



(Deleted)

Figure 2—Grounding of unused CTs

A connection to ground is made in an accessible location to facilitate its temporary removal and reconnection for test purposes. The connection is not made through fuses or through contacts of any testing or switching device that can be inadvertently opened or left open. Sliding link terminal blocks also are considered inappropriate for this reason.

5.6 Minimum size of conductor for ground connection

The grounding conductor is as large as (or larger than) the secondary phase conductors. As required by NESC®, copper wire of No. 12 AWG size (area = 3.310 mm² at 20 °C) or larger is used for mechanical reasons and for reason of current-carrying capacity. If made of another metal, the wire is chosen such that its conductance, strength, and current-carrying capacity are equal to [or greater than](#) that of No. 12 AWG (area = 3.310 mm² at 20 °C) copper wire.

In some cases, a circuit cannot be grounded directly, but the need for grounding is met by grounding through the coil of a device. In such cases, a wire of any size is considered adequate for use inside the device so long as it has sufficient mechanical strength to withstand electromagnetic forces caused by the flow of current in the device. All conductors external to the device, through which the circuit is connected to ground, should conform to the requirements outlined in the preceding paragraph.

5.7 Ground connection isolation test facilities

5.7.1 General

The instrument transformer secondary circuits are connected to ground in a way that permits convenient removal of the ground connection for isolating or testing as stated in item b) of 5.3. It is usual to ensure that removal of a connection to ground on one circuit does not interfere with maintaining a ground on any other circuit. Because of the different configurations used for instrument transformer secondary circuits, it is not always readily apparent how this is accomplished. The following discussion and examples illustrate typical methods of providing the isolation test facility for secondary circuits connected to VTs and CTs.

5.7.2 VT secondary circuits

5.7.2.1 Background

VT secondary circuits are used in electric power systems in different forms. One of the forms consists of using the outputs of VTs for providing voltages to meters and relays. Another form consists of circuits that provide the outputs of VTs to synchrosopes. The third form consists of the circuits that provide the outputs of station distribution transformers to meters and relays. These applications are reviewed in 5.7.2.1 through 2, 5.7.2.3, and 5.7.2.4.

5.7.2.2 Typical applications

Typical VT circuits used for metering and relaying are shown in Figure 1. In the three-phase, four-wire configuration, the neutral of the secondary windings of the VTs is provided for connecting phase-to-neutral loads. The neutral is normally grounded at the first point of application, as is shown in Figure 1. In this configuration, a phase-to-neutral fault on the VT secondary circuit appears to protective relays to be a phase-to-neutral fault on the power system.

An alternative method sometimes used is to ground one phase (usually phase-B) instead of the neutral. A phase-A or phase-C to ground fault on the secondary circuit now appears to be a phase-A to phase-B or phase-C to phase-B fault on the power system. There is also a possibility of a neutral-to-ground fault, a phase-B to neutral fault, or a short circuit of a phase-to-neutral load on the secondary circuit of the VT. It is desirable that the impact of such short circuits in the secondary windings of VTs on the coordination of protection devices be evaluated.